Except for the instances where a phase inversion is provided, the phase adjustment in each cycle is limited to a particular magnitude. For example, when sixteen (16) amplifiers are provided in the ring oscillator **186**, each phase adjustment may be limited to that provided by two (2) successive amplifiers in the ring oscillator **186**. This enhances the stability in adjusting the phase of the clock signals on the line **128** so that the signal x_o occurs at the zero crossing of the clock signals.

When a phase inversion of 90° occurs, an adjustment in the phase of the clock signals on the line **128** in FIG. **11** is not made at the same time as a result of the operation of the high gain error generator **132**. This enhances the stability in the phase adjustments. An adjustment in the phase of the clock signals is also not made during the time between the occurrence of the successive packets.

When the signal on the line **146** in FIGS. **11** and **16** indicates the occurrence of the digital signals representing the information or data in a packet, the select stage **180** passes a signal to the loop filter **126** to provide a gain of K_3 or K_2 in the loop filter depending upon the relative characteristics of the curve represented by $\hat{x}_1$, x_o and $\hat{x}_2$ in FIG. 14. The multiplexer **182** then selects one of the amplifiers **188***a*–**188***g* for the passage of a signal to the clock line **128** in accordance with the operation of the loop filter **126**.

Although this invention has been disclosed and illustrated with reference to particular embodiments, the principles involved are susceptible for use in numerous other embodiments which will be apparent to persons skilled in the art. The invention is, therefore, to be limited only as indicated by the scope of the appended claims.

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We claim:

1. In combination for use in a system providing signals having individual ones of a plurality of analog levels to represent information,

a hub,

a plurality of computers,

a plurality of pairs of twisted wires, each plurality being disposed between the hub and an individual one of the computers to transmit signals between the individual one of the computers and the hub,

each of the computers including a receiver for receiving from the hub the signals having the plurality of analog levels,

first means responsive in each of the computers to the received signals for providing a digital conversion of the received signals at a particular frequency,

second means responsive in each of the computers to the digitally converted signals from the first means in such computer for regulating such digital conversion by the first means at the particular frequency,

third means responsive in each of the computers to the digitally converted signals from the first means in such computer for providing an adaptive equalization of such digitally converted signals from the first means and for selecting, after such adaptive equalization, individual ones of the analog levels closest in magnitude to the digitally converted signals, and

fourth means in each of the computers for decoding the individual ones of the analog levels selected by the third means in such computer to recover the information represented by the received signals.

2. In a combination as set forth in claim **1**,

fifth means responsive in each of the computers to the received signals in such computer for providing an automatic gain control in such signals and for intro-

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ducing the gain controlled signals from the fifth means to the first means in such computer, and

sixth means responsive in each of the computers to the signals from the first means in such computer for regulating the gain in the fifth means in such computer.

3. In a combination as set forth in claim 1,

the third means in each of the computers including a feed forward equalizer and a decision feedback equalizer for for correcting for distortions in the digital conversion from the second means and including means responsive to the signals from the feed forward equalizer and the decision feedback equalizer for selecting, for introduction to the fourth means, the analog levels closest in magnitude to the digital conversions.

4. In a combination as set forth in claim 1,

the signals received in each computer from the hub being in the form of packets each having a plurality of timing signals at the beginning of such packet, and

the second means including fifth means responsive to the timing signals in each packet for regulating the frequency of the digital conversion of the received signals by the first means at the particular value.

5. In a combination as set forth in claim 1,

the signals received in each computer from the hub being in the form of packets each including a plurality of signals representing data, and

the second means including fifth means responsive to the signals representing data in each packet for regulating at the particular frequency the digital conversion of the received signals by the first means.

6. In a combination as set forth in claim 1,

the signals received in each computer from the hub being in the form of packets each including a plurality of timing signals at the beginning of such packet and each including a plurality of signals following such timing signals and representing data,

the second means including fifth means responsive to the timing signals in each packet for providing a coarse control in regulating at the particular frequency the digital conversion of the received signals by the first means, and

the second means including sixth means responsive to the signals representing data in each packet for providing a fine control in regulating at the particular frequency the digital conversion of the received signals by the first means.

7. In combination for use in a system providing signals having individual ones of a plurality of analog levels to represent information,

a hub,

a computer displaced from the hub,

a plurality of twisted pairs of wires extending between the hub and the computer,

one of the twisted pairs of wires providing only for the transmission of the signals from the computer to the hub,

a second one of the twisted pairs of wires providing only for the reception at the computer of the signals from the hub,

third and fourth ones of the twisted pairs of wires providing for the transmission of the signals from the computer to the hub and the reception at the computer of the signals from the hub,

first means responsive at the computer to the signals received at the computer through the second, third and

fourth ones of the twisted pairs for providing a digital conversion of such signals at a particular frequency,

timing recovery means responsive to the digitally converted signals from the first means for regulating the frequency of the digital conversion by the first means at the particular frequency, and

digital adaptive equalizer means responsive to the signals from the first means for selecting individual ones of the analog levels closest in the plurality to the magnitudes of the digitally converted signals.

8. In a combination as set forth in claim 7,

second means responsive at the computer to the received signals for providing an automatic gain control of such signals and for introducing such gain controlled signals to the first means, and

third means responsive to the digitally converted signals from the first means for regulating the gain of the signals from the second means at a particular value,

the digital adaptive equalizer means being responsive to the digitally converted signals from the first means for selecting the individual one of the analog levels closest in the plurality to the signals from the second means.

9. In a combination as set forth in claim 7,

second means responsive to the selection by the digital adaptive equalizer means of the individual ones of the analog levels in the plurality for recovering the information represented by such analog levels.

10. In a combination as set forth in claim 7,

the received signals being in the form of packets each including a plurality of timing signals in a preamble at the beginning of such packet and including a plurality of data signals after the preamble, and

the timing recovery means including second means responsive to the timing signals in the preamble in each packet for regulating at the particular value the frequency at which the first means provides a digital conversion of the signals received at the computer.

11. In a combination as set forth in claim 7,

the received signals being in the form of packets each including a plurality of timing signals at the beginning of such packet and including a plurality of data signals after the preamble,

the timing recovery means including third means responsive to the timing signals in the preamble in each packet for regulating, at the particular frequency, the frequency at which the first means provides the digital conversion of the digital signals received at the computer, and

fourth means responsive to the selection by the digital adaptive equalizer means of the individual ones of the analog levels for recovering the data represented by such analog levels.

12. In a combination as set forth in claim 8,

the received signals being in the form of packets each including a plurality of timing signals at the beginning of such packet and including a plurality of data signals after the preamble,

the timing recovery means including third means responsive to the timing signals in the preamble in each packet for regulating at the particular frequency, the frequency at which the first means provides a digital conversion of the signals received at the computer, and

fourth means responsive to the selection by the digital adaptive equalizer means of the individual ones of the analog levels for recovering the data represented by such analog levels.

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13. In a combination as set forth in claim 12,

the timing recovery means including fifth means for regulating, at the particular frequency in accordance with the pattern of the digital conversion of the progressive ones of the timing signals in each packet, the frequency at which the first means provides a digital conversion of the timing signals received at the computer,

the timing recovery means including sixth means for regulating, at the particular frequency in accordance with the pattern of the digital conversion of the progressive ones of the data signals in each packet, the frequency at which the first means provides a digital conversion of the data signals received at the computer.

14. In combination for use in a system providing signals having individual ones of a plurality of analog levels to represent information,

a hub,

a computer displaced from the hub,

a plurality of twisted pairs of wires between the hub and the computer, individual ones of the twisted pairs of wires either transmitting or receiving the digital signals and other ones of the twisted pairs of wires selectively transmitting and receiving the digital signals,

first means responsive to the signals received in the twisted pairs of wires for providing a digital conversion of the received signals at a particular rate,

second means responsive to the digitally converted signals from the first means for regulating the rate of the digital conversion of the received signals at the particular rate, and

third means responsive to the digitally converted signals from the first means for converting the magnitudes of such digitally converted signals to the individual ones of the analog levels closest to such magnitudes and for recovering the information represented by such analog levels.

15. In a combination as set forth in claim 14,

fourth means responsive to the digitally converted signals from the first means for providing an automatic gain control of such signals and for introducing such gain controlled signals from the fourth means to the first means.

16. In a combination as set forth in claim 14,

the received signals being provided in packets, and

the second means including fourth means responsive to the signals in each packet for regulating the rate of the digital conversion of the received digital signals in such packet at the particular value, and

the third means being responsive to the digitally converted signals in each packet from the first means for recovering the information represented by such digitally converted signals.

17. In a combination as set forth in claim 14,

the received signals being provided in packets each including a plurality of timing signals at the beginning of such packet, and

the second means including fourth means responsive to the timing signals in each packet for regulating the rate of the digital conversion of the received signals at the particular rate.

18. In a combination as set forth in claim 15,

the received signals being provided in packets each including the progressive data signals in the preamble

in such packet in individual patterns representative of the data in such packet, and

the second means including fourth means responsive to the individual patterns of the progressive data signals in each packet for regulating the rate of the digital conversion of the received data signals in such packet at the particular value.

19. In a combination as set forth in claim 15,

the received signals being provided in packets each including a plurality of timing signals in a preamble at the beginning of such packet and each including data signals in such packet after the timing signals in such packet, for regulating the rate of the digital conversion of the received data signals at the particular rate,

the second means including sixth means responsive to the timing signals in the preamble in each packet for regulating the rate of the digital conversion of the data signals in such packet at the particular rate, and

the second means including seventh means responsive to the individual patterns of the data signals in each packet for regulating the rate of the digital conversion of the received data signals in such packet at the particular rate.

20. In a combination as set forth in claim 14,

the third means including digital adaptive equalizer means responsive to the digitally converted signals from the first means for selecting for each of such digitally converted signals the individual one of the analog levels closest to the magnitude of such digitally converted signal and including fourth means responsive to the selected amplitude levels from the digital adaptive equalizer means for recovering the information represented by such amplitude levels.

21. In a combination as set forth in claim 20,

the received signals being provided in packets each having the data signals in such packet in individual patterns representative of the information in such packet,

the second means including fifth means responsive to the individual patterns of the individual ones of the analog levels selected by the digital adaptive equalizer means in each packet for regulating the rate of the digital conversion of the received signals in such packet at the particular value.

22. In combination for use in a system providing signals having individual ones of a plurality of analog levels representing information,

a hub,

a computer displaced from the hub,

a plurality of twisted pairs of wires between the hub and the computer, individual ones of the twisted pairs of wires either transmitting or receiving the signals and other ones of thc twisted pair of wires selectively transmitting and receiving the signals,

the signals being provided in packets each including a preamble providing a plurality of timing signals and, after the preamble, a plurality of data signals representing the information,

first means responsive to the signals received in the twisted pairs of wires in the plurality for providing a digital conversion of the received signals at a particular rate,

second means responsive to the timing signals in the preamble in each packet and providing a first gain for regulating at the particular rate the digital conversion by the first means of the received signals,

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third means responsive to the data signals representing the information in each packet and providing a second gain lower than the first gain for regulating at the particular rate the digital conversion by the first means of the received signals, and

fourth means responsive to the digital conversions from the first means of the data signals for converting such digital conversions to the information represented by such digital conversions.

23. In a combination as set forth in claim 22,

the fourth means being responsive to the digital conversions from the first means for selecting, for each of the data signals representing information in the packets, the individual ones of the analog levels closest in the plurality to the magnitude of such digital conversions.

24. In a combination as recited in claim 22,

the third means including fifth means responsive to first individual patterns of the data signals representing the information in each packet for providing a first particular value for the second gain in the regulation at the particular rate of the digital conversion of the received signals by the third means, and

the third means including sixth means responsive to second individual patterns of the data signals representing the information in each packet for providing a second particular value of the second gain, different from the first particular value of the second gain, in the regulation at the particular rate of the digital conversion of the received signals by the third means.

25. In a combination as recited in claim 24,

the fourth means including digital adaptive equalizer means responsive to the magnitudes of the digital conversions from the first means for selecting individual ones of the analog levels closest in the plurality to such magnitudes,

the fourth means also including fifth means responsive to the individual ones of the analog levels selected by the digital adaptive equalizer means for decoding such selected analog levels to recover the information represented by such analog levels.

26. In a combination as recited in claim 22,

fifth means responsive to the received signals for providing an automatic gain control of such signals, and

sixth means responsive to the digital conversions from the first means for regulating the automatic gain of the signals from the fifth means at a particular value.

27. In a combination as set forth in claim 25,

sixth means responsive to the received signals for providing an automatic gain control of such signals, and

seventh means responsive to the digital conversions from the first means for regulating the gain of the signals from the fifth means at a particular value.

28. In combination for use in a system providing signals having individual ones of a plurality of analog levels representing information and providing a computer and a hub displaced from the computer and a plurality of twisted pairs of wires between the hub and the computer, individual ones of the twisted pairs of wires either transmitting or receiving the signals and other ones of the twisted pair of wires selectively transmitting and receiving the signals,

the signals being provided in packets each having a preamble providing a plurality of timing signals and, after the preamble, a plurality of data signals representing the information,

first means disposed in the computer and responsive to the signals received in the twisted pairs of wires for pro-

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viding a digital cooversion of the received signals at a particular rate,

second means disposed in the computer and responsive to the preamble in each packet for regulating with a first gain factor the digital conversion of the received signals at the particular rate,

third means disposed in the computer and responsive to the digital conversions of the data signals representing the information in each packet for regulating with a second gain factor lower than the first gain factor the digital conversion of such data signals at the particular rate, and

fourth means disposed in the computer and responsive to the digital conversions of the data signals from thc first means for convertiog such digital conversions to the information represented by such digital conversions.

29. In a combination as set forth in claim 28,

the fourth means being respoosive to the digital conversioos of the data signals from the first means for selectiog, for each of such digital conversions, the individual one of the analog levels closest io magnitude to such digital conversions.

30. In a combinatioo as recited in claim 28,

the third means including fifth means responsive to first individual patterns of the digital conversioos of the data signals in each packet for providiog a regulation, with a first particular value of the first gain factor at the particular rate, of such digital conversions, and

the third means iocluding sixth means responsive to second individual patterns of the digital conversions of the data signals in each packet for providing a regulation with a second particular value of the gain factor different from the first particular value of the second gain factor, of such digital conversions.

31. In a combination as recited in claim 30,

the fourth means including digital adaptive equalizer means responsive to the digital conversions of the data signals from the first means for selecting iodividual ones of the analog levels closest in magnitude in the plurality to the digital conversions,

the fourth means also including fifth means responsive to the digital conversions of the data signals from the digital adaptive equalizer means for decoding the analog levels selected by the digital adaptive equalizer means to recover the information represented by such analog levels.

32. In a combination as recited in claim 28,

fifth means responsive to the received signals for providing an automatic gain control of such signals, and

sixth means responsive to the digital conversions from the first means for regulating the gain of the signals from the fifth means at a particular value.

33. In a combination as set forth io claim 31,

fifth means responsive to the received signals for providing an automatic gain control of such signals, and

sixth means responsive to the digital conversions from the first means for regulating the gain of the signals from the fifth means at a particular value.

34. In combioation for use in a system providing signals having individual ones of a plurality of analog levels to represent information and including a hub and a computer displaced from the hub and including a plurality of twisted pairs of wires extending betweeo the hub and the computer, one of the twisted pairs of wires providing only for the transmission of the signals from the computer to the hub, a

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second one of the twisted pairs of wires providing only for the reception at the computer of the signals from the hub, third and fourth ones of the twisted pairs of wires selectively providing for the transmission of the signals from the computer to the hub and the reception at the computer of the signals from the hub,

first means responsive at the computer to the signals received at the second, third and fourth ones of the twisted pairs for providing a digital conversion of such signals at a particular value of frequency,

timing recovery means responsive at the computer to the digital conversions from the first means for regulating at the particular value the frequency of the digital conversions by the first means, and

digital adaptive equalizer means responsive at the computer to the signals from the first means for selecting individual ones of the analog levels closest in magnitude to the digital conversions from the first means.

35. In a combination as set forth in claim **34**,

second means responsive at the computer to the received signals for providing an automatic gain control of such signals and for introducing such signals to the first means, and

third means responsive at the computer to the digital conversions from the first means for regulating the gain of the signals from the second means at a particular value,

the digital adaptive equalizer means being responsive to the digital conversions from the first means for selecting the individual ones of the analog levels closest in magnitude to the digital conversions from the first means.

36. In a combination as set forth in claim **34**,

second means responsive at the computer to the signals from the digital adaptive equalizer means for recovering the information represented by the analog levels selected by the digital adaptive equalizer means.

37. In a combination as set forth in claim **34**,

the received signals being in the form of packets each including a plurality of timing signals in a preamble at the beginning of such packet and including data signals after the preamble, and

the timing recovery means including second means responsive to the timing signals in each packet for regulating at the particular value the frequency at which the first means provides a digital conversion of the signals received at the computer.

38. In a combination as set forth in claim **34**,

the received signals being in the form of packets each including a plurality of timing signals at the beginning of such packet and including data signals after the preamble,

the timing recovery means including second means responsive to the timing signals in each packet for regulating at the particular value the frequency at which the first means provides the digital conversion of the data signals received at the computer in each packet, and

third means responsive to the analog levels selected by the digital adaptive equalizer means for the data signals in each packet for recovering the data represented by such selected analog levels.

39. In a combination as set forth in claim **35**,

the received signals being in the form of packets each including a plurality of timing signals at the beginning

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of such packet and including data signals after the preamble,

the timing recovery means including fourth means responsive to the timing signals in each packet for regulating at the particular value the frequency at which the first means provides a digital conversion of the signals received at the computer in each packet, and

fifth means responsive to the analog levels selected by the digital adaptive equalizer means in each packet for recovering the data represented by such selected analog levels.

40. In a combination as set forth in claim **38**,

fifth means disposed at the computer for regulating at the particular value, in accordance with the pattern of successive ones of the signals in each packet, the frequency at which the first means provides a digital conversion of the signals received at the computer.

41. In combination for use in a system including a hub and a plurality of twisted pairs of wires to provide packets of signals where each packet includes a preamble defined by a plurality of timing signals and includes a plurality of data signals following the preamble, each of the data signals having an individual one of a plurality of analog values to represent information and where the timing signals and the data signals in the packets are transmitted through the twisted pairs of wires from the hub,

a computer displaced from the hub for receiving the packets including the timing signals in preamble and the data signals representing the information,

the computer including a plurality of channels each responsive to the packets received by the computer from an individual one of the pairs of the twisted wires,

each individual one of the channels including first means for providing digital conversions at the particular rate of the signals received in each packet in such channel,

each individual one of the channels including second means responsive to the digital conversions from the first means in each of the channels for operating upon such signals to regulate the digital conversions of the received signals by the first means at the particular rate, and

each individual one of the channels including third means responsive to the digital conversions of the data signals from the first means in such channel for selecting the individual ones of the analog values in the plurality closest in magnitude to the digital conversions of the data signals received in such channel.

42. In a combination as set forth in claim **41**, including,

fourth means responsive to the analog values selected by the third means in each of the channels for decoding such analog values and for combining such decoded analog values for the different channels to recover the information.

43. In a combination as set forth in claim **41** wherein

the second means in each individual one of the channels includes fourth means responsive to the timing signals in the packets in such channel for operating upon such timing signals to regulate the digital conversions of the received signals by the first means at the particular rate and wherein

the second means in each individual one of the channels includes sixth means responsive to the data signals representing the information in the packets in such channel for operating upon such data signals to regulate the digital conversion of the received signals by the first means at the particular rate.

44. In a combination as set forth in claim 42 wherein

the second means in each of the channels includes fifth means responsive to the timing signals in the packets in such channel for operating upon such timing signals to regulate with a first particular gain factor the digital conversion of the received signals by the first means at the particular rate and wherein

the third means in each of the channels includes sixth means responsive to the digital conversions of the data signals representing the information in the packets in such channel for operating upon such digital conversions to regulate with a second particular gain factor the digital conversion of the data signals by the first means at the particular rate and wherein

the second particular gain factor is less than the first particular gain factor.

45. In combination for use in a system including a hub and a plurality of twisted pairs of wires to provide packets of signals where each packet includes a preamble defined by a plurality of timing signals and includes a plurality of data signals having individual ones of a plurality of analog levels to represent information and where

the signals in the packets are transmitted through a plurality of the twisted pairs of wires from the hub,

a computer displaced from the hub for receiving the packets including the timing signals in the preamble and the data signals transmitted from the hub,

the computer including a plurality of channels each individual one of which receives the signals in the packets in at least an individual one of the twisted pairs,

each individual one of the channels including first means for providing an automatic gain control of the signals in the packets in such channel,

each individual one of the channels including second means for providing a digital conversion at a particular rate of the signals in the packets from the first means in such channel,

each individual one of the channels including third means responsive to the signals from the second means in such channel for regulating thc gain of the signals from the first means in such channel at a particular value,

each individual one of the channels including fourth means responsive to the digital conversions from the second means in such channel for selecting the individual ones of the analog levels in the plurality closest in magnitude to the digital conversions of the data signals in each packet from the second means,

each individual one of the channels including fifth means responsive to the digital conversions from the second means for regulating at the particular rate the digital conversion of the signals in thc packets in such channel by the second means.

46. In a combination as set forth in claim 45,

the fifth means in each individual one of the channels including sixth means responsive to the timing signals in the preamble in the packets in such channel for providing a first regulation in the digital conversions by the second means of the signals in such packets at the particular rate, and

the fifth means in each individual one of the channels including seventh means responsive to the data signals representing the information in the packets in such channel for providing a second regulation in the digital conversions by the second means of the data signals in such packets at the particular rate,

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the first regulation being different from the second regulation.

47. In a combination as set forth in claim 45,

the fifth means in each individual one of the channels including sixth means responsive to the timing signals in the preamble in the packets in such channel for providing a first regulation with a first gain factor in the conversion by the second means of the signals in such packets at the particular rate, and

the fifth means in each individual one of the channels including seventh means responsive to the data signals representing the information in the packets in such channel for providing a second regulation with a second gain factor in the digital conversion by the second means of the data signals in such packets at the particular rate,

the second gain factor being less than the first gain factor, and

eighth means for recovering the information represented by the individual ones of the analog levels selected by the fourth means.

48. In a combination as set forth in claim 47,

the seventh means for each individual one of the channels including eighth means responsive to a first pattern of the digital conversions of the data signals representing the information in the packets in such channel for providing a third regulation with a third gain factor in the digital conversions by the second means of the data signals in such packets at the particular rate,

the third gain factor being less than the second gain factor.

49. In a combination as set forth in claim 43,

the fourth means for each individual one of the channels including a feed forward equalizer, a decision feedback equalizer, a multi-level data slicer and an adder responsive to the outputs from the feed forward equalizer and the decision feedback equalizer for providing an output to the multi-level data slicer, the feed forward equalizer receiving the output from the second means for such channel and the decision feedback equalizer receiving the output of the data slicer, and

means for decoding the outputs from the data slicers in the different channels and for combining such outputs to recover the information.

50. In a combination as set forth in claim 45,

sixth means for decoding the analog levels selected by the fourth means for the digital conversions of the data signals in the different channels and for combining such decoded analog levels to recover the information represented by the such digital conversions.

51. In a combination as set forth in claim 49,

there being a plurality of data slicers each included in the fourth means in an individual one of the channels for selecting the individual ones of the analog levels closest in magnitude to the digital conversions of the data signals in such channel,

sixth means for decoding the analog levels selected by the second means for the digital conversions of the data signals in the different channels and for combining such decoded analog levels to recover the information represented by the digital conversions of the data signals in the different channels, and

means for recovering the information represented by the analog levels selected by the data slicer in each channel from the digital conversions of the data signals in such channels.

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52. In combination for use in a system providing signals having individual ones of a plurality of analog levels to represent information,

a hub,

a computer,

a plurality of pairs of twisted wires connecting the hub and the computer,

a first one of the twisted pairs of wires being only for transmission of the signals from the computer to the hub, a second one of the twisted pairs of wires being only for the reception of the digital signals at the computer from the hub and third and fourth ones of the twisted pairs of wires being for the selective transmission of the signals from the computer to the hub and for the selective reception of the signals at the computer from the hub,

first means at the computer for transmitting the signals through the individual ones of the first, third and fourth pairs of the twisted wires from the computer to the hub,

second means at the computer for receiving the signals passing through the individual ones of the second, third and fourth pairs of the twisted wires from the hub,

a media access controller for establishing a priority between the signals received by the computer and the signals transmitted by the computer when the received and transmitted signals occur simultaneously,

a plurality of third means each responsive in the computer to the digital signals received through an individual one of the second, third and fourth twisted pairs of wires for providing a digital conversion of such signals at a particular rate,

a plurality of fourth means each responsive in the computer to the digital conversions of the signals from an individual one of the third means in the plurality for regulating the digital conversions by such individual one of the third means at the particular rate, and

a plurality of fifth means each responsive in the computer to the digital conversions from an individual one of the third means in the plurality for establishing for each of such digital conversions an individual one of the plurality of analog levels closest in magnitude to such digital conversions from the first means.

53. In a combination as set forth in claim 52,

sixth means responsive to the analog levels established by the fifth means in the plurality for decoding such analog levels and for combining the decoded analog levels to recover the information represented by such analog levels.

54. In a combination as set forth in claim 52,

a plurality of sixth means each responsive in the computer to the signals received through an individual one of the second, third and fourth twisted pairs of lines for providing an automatic gain control of such signals, and

a plurality of seventh means each responsive in the computer to the digital conversions from an individual one of the third means in the plurality for regulating the gain of the signals from an individual one of the fourth means in the plurality at a particular value.

55. In a combination as set forth in claim 52,

the signals received by the computer through the second, third and fourth of the twisted pairs of wires being provided in packets each having a preamble defined by a plurality of timing signals and each providing, after the preamble, data signals representing information,

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each of the fourth means in the plurality including sixth means responsive to the digital conversions of the timing signals in the preamble in the packets from an individual one of the third means in the plurality for regulating in a first relationship such digital conversions at the particular rate,

each of the fourth means in the plurality including seventh means responsive to the digital conversions of the data signals following the preamble in the packets from an individual one of the third means in the plurality for regulating in a second relationship such digital conversions at the particular rate,

the second relationship being different from the first relationship.

56. In a combination as set forth in claim 55,

the regulation in the first relationship being operative with a first gain factor,

the regulation in the second relationship being operative with a second gain factor,

the second gain factor being less than the first gain factor, and

eighth means responsive to the analog levels established by the fifth means in the plurality for decoding such analog levels and for combining the decoded analog levels to recover the information represented by such decoded analog levels.

57. In a combination as set forth in claim 56,

a plurality of ninth means each responsive to the signals received through an individual one of the second, third and fourth twisted pairs of wires for providing an automatic gain control of such signals, and

a plurality of tenth means each responsive to the digital conversions from an individual one of the third means in the plurality for regulating at a particular value the gain of the signals from an individual one of the ninth means in the plurality.

58. In combination for use in a computer included in a system having a hub for providing packets of signals where each packet includes a preamble defined by a plurality of timing signals and includes a plurality of data signals having individual ones of a plurality of analog levels to represent information,

first means for receiving the packets of the signals from the hub,

second means responsive to the signals in the packets received from the hub for providing a digital conversion of such signals at a particular rate,

third means responsive to the digital conversions from the second means and the timing signals in the preamble in each packet for producing a first output dependent upon the occurrence of such timing signals relative to the digital conversions from the second means,

fourth means responsive to the digital conversions from the second means and the data signals following the preamble in each packet for producing a second output dependent upon the occurrence of the data signals in the packets relative to such digital conversions,

fifth means for providing clock signals at a rate constituting an integral multiple of the particular rate, and

sixth means selectively responsive to the first output from the third means and the second output from the fourth means for passing individual ones of the clock signals from the fifth means to the second means in accordance with the selected ones of the first and second outputs to obtain a regulation of the digital conversions by the second means at the particular rate.

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59. In a combination as set forth in claim **58**,

the second means being operative to provide the digital conversion of the signals in the packets received from the hub in accordance with the individual ones of the clock signals passed by the sixth means,

the third means being operative at a first gain factor to produce the first output, and

the fourth means being operative at a second gain different from the first gain to produce the second output.

60. In a combination as set forth in claim **58**,

the second means being operative to provide the digital conversion of the signals in the packets received from the hub in accordance with the individual ones of the clock signals passed by the sixth means, and

seventh means responsive to the digital conversions by the second means of the data signals in the packets received from the hub for operating upon such data signals to recover the information represented by such digital conversions.

61. In a combination as set forth in claim **59**,

seventh means responsive to the digital conversions of the data signals from the second means for selecting the individual ones of the analog levels closest in magnitude to the peaks of such digital conversions, and

eighth means for recovering the information from the individual ones of the analog levels selected by the seventh means.

62. In a combination as set forth in claim **58**,

the fifth means including a plurality of amplifiers connected in a ring oscillator,

each of the amplifiers being connected in the ring oscillator to pass a signal on a cyclic basis relative to the signals passed by the other amplifiers in the ring oscillator,

seventh means for selectively passing the first output from the third means during the occurrence of the timing signals in the preamble in each packet and for selectively passing the second output from the fourth means during the occurrence of the data signals following the preamble in each packet, and

eighth means for passing the signal from an individual one of the amplifiers in the fifth means for each packet in response to the output from the seventh means for such packet.

63. In a combination as set forth in claim **58**,

seventh means for transmitting the signals from the computer to the hub, and

eighth means in the computer for providing a priority between the signals transmitted by the computer and the signals received by the computer when the transmitted and received signals occur simultaneously at the computer.

64. In combination for use in a system having a hub for providing packets of signals where each packet includes a preamble defined by a plurality of timing signals and includes a plurality of data signals having individual ones of a plurality of analog levels to represent information,

first means for receiving the signals in each packet,

second means responsive to the signals received in each packet for providing digital conversions of such signals at a particular rate,

third means responsive to the digital convertsions from the second means for producing individual ones of the analog levels in the plurality, the individual one of the

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analog levels for each of the digital convertsions being that analog level closest to the peak amplitude of such digital convertsion,

fourth means responsive to the digital conversions from the second means in each packet for regulating the digital conversions of the received signals in each packet at the particular rate, and

fifth means responsive to the individual ones of the analog levels from the third means for converting such analog levels to the information represented by the data signals in the packets.

65. In a combination as set forth in claim 64,

the second means including sixth means responsive to the digital conversions in each preamble in each packet for regulating the digital conversions at the particular rate, and

the second means including seventh means responsive to the digital conversions of the data signals following each preamble in each packet for regulating such digital conversions at the particular rate.

66. In a combination as set forth in claim 64,

each of the digital conversions from the second means having a peak amplitude and a zero crossing,

the fourth means including sixth means responsive to first patterns in the peak amplitudes and zero crossings of the digital conversions produced by the second means for regulating with a first gain factor such digital conversions at the particular rate, and

the fourth means including seventh means responsive to second patterns in the peak amplitudes and the zero crossings of the digital conversions produced by the second means for regulating with a second gain factor such digital conversion at the particular rate,

the second gain factor being different than the first gain factor.

67. In a combination as set forth in claim 64,

the third means including a first equalizer, a data slicer, an adder and a second equalizer, the first equalizer being responsive to the digital conversions from the second means and the data slicer providing digital signals and the second equalizer being responsive to the digital signals from the data slicer and the adder being responsive to the signals from the first and second equalizers and the data slicer being responsive to the digital signals from the adder for producing from the data slicer the individual ones of the analog levels in the plurality, and

the fifth means being responsive to the individual ones of the plurality of amplitude levels from thc third means for converting such individual ones of the analog levels to the information represented by the digital signals in the packets.

68. In combination for use in a system having a hub for providing packets of signals where each packet includes a preamble defined by a plurality of timing signals and includes a plurality of data signals following the preamble and having individual ones of a plurality of analog levels to represent information,

first means for receiving the signals in each packet,

second means for providing digital conversions of the received signals in each packet at a particular rate,

third means responsive to the digital conversions from the second means during the occurrence of the timing signals in the preamble in each packet for determining the amplitudes and polarities of such digital conver-

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sions at tbe times assumed by the third means to constitute the peaks and zero crossings of such digital conversions,

fourth means responsive to first patterns in the amplitudes determined by the third means at the times assumed by the third means to constitute the peaks and zero crossings of such digital conversions for providing a first phase adjustment in the digital conversions from the second means,

fifth means responsive to second patterns in the amplitudes determined by the third means at the times assumed by the third means to constitute the peaks and zero crossings of such digital conversions for providing a second phase adjustment in the digital conversions from the second means, and

sixth means responsive to the digital conversions from the second means for recovering the information represented by the signals in the packets,

the first phase adjustment being different from the second pbase adjustment.

69. In a combination as set forth in claim **68** wherein

the third means provides first and second determinations in each cycle of the amplitudes of the digital conversions from the second means at times assumed by the third means to correspond to the peaks and zero crossings in such cycle, and

the fourth means provides the first phase adjustments when the amplitude determined by the third means at the times assumed by the third means to be the peaks of such digital conversions is greater than the amplitudes, amplified by a particular constant, determined by the third means at the times assumed in the third means to be the zero crossings of sucb digital conversions.

70. In a combination as set forth in claim **68** wberein

the third means respectively provides first and second determinations in each cycle of the digital conversions from the second means during the preamble in eacb packet at times assumed by the third means to correspond to the peak and zero crossings of the digital conversions in such cycle and

the fourth means provides the first pbase adjustments during the preamble in each packet when the amplitudes determined by the third means at the times assumed by the third means to be the peaks of such digital conversions is greater than the amplitudes, amplified by a particular gain, determined by the third means at the times assumed by the third means to be the zero crossings of such digital conversions and

the fifth means provides the second pbase adjustments during the preamble in each packet when the amplitudes determined by the third means at the times assumed by the third means to be the peaks of the digital conversions is less than the amplitudes, amplified by the particular gain factor, determined by the third means at the times assumed by the third means to be the zero crossings of such digital conversions.

71. In a combination as set forth in claim **70** wberein

tbe fourth means provides the first phase adjustments in each cycle during the preamble in each packet until the product of the amplitudes of the first and second determinations in sucb cycle is zero, and

the fifth means provides the second phase adjustments in each cycle during the preamble in each packet until the product of the amplitudes of the first and second determinations of the amplitudes in such cycle is zero.

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72. In combination for use in a system having a hub for providing packets of signals where each packet includes a preamble defined by a plurality of timing signals and includes a plurality of data signals following the preamble and having individual ones of a plurality of analog levels to represent information,

first means for receiving the signals in each packet,

second means for providing a digital conversion of the received signals in each packet at a particular rate,

third means for providing digital outputs at progressive times during each digital conversion from the second means,

fourth means for operating upon the digital conversions from the second means during the occurrence of the timing signals in the preamble in each packet at times assumed by the fourth means to constitute the peaks and zero crossings of such digital conversions to determine the amplitudes and polarities of the digital conversions at such times,

fifth means responsive in each cycle of the timing signals in the preamble in each packet to the amplitudes and polarities determined for the digital conversions in such cycle to select a particular one of the digital outputs at the progressive times from the third means for providing the digital conversions by the second means,

sixth means responsive to the digital conversions by the second means of the data signals following the preamble in each packet for selecting the analog levels of such data signals closest in magnitudes to the peaks of the digital conversions, and

seventh means responsive to the analog levels selected by the sixth means for recovering the information represented by such analog levels.

73. In a combination as set forth in claim 72,

the fifth means including eighth means responsive to the magnitudes of the digital conversions determined by the fourth means at the times assumed by the fourth means to be the peak of the digital conversions during the preamble in each packet and at the times assumed by the fourth means to be the zero crossings of such digital conversions during the preamble in such packet for providing a particular adjustment in the selection of the particular one of the digital outputs at the progressive times from the third means in obtaining the digital conversions by the second means.

74. In a combination as set forth in claim 72,

the fifth means including eighth means responsive to the magnitudes of the digital conversions determined by the fourth means at the times assumed by the fourth means to be the peak of the digital conversions after the preamble in each packet and the magnitudes of the digital conversions determined by the fourth means at the times assumed by the fourth means to be the zero crossing of such digital conversions after the preamble in such packet for providing a particular adjustment in the selection of the particular one of the digital outputs at the progressive times from the third means in obtaining the digital conversions by the second means.

75. In a combination as set forth in claim 72,

the sixth means including eighth means responsive to the signals from the second means in representation of the information in the packets for selecting individuals one of a plurality of pre-selected amplitude levels, the individual one of the pre-selected amplitude levels being that closest for each of the digital signals to the

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amplitude of such digital signal from the second means, and

automatic gain control means for regulating the gain of the seventh means including ninth means responsive to the individual ones of the

automatic gain control means for regulating the gain of the digital conversions from the second means at a particular value.

76. In combination for use in a system having a hub for providing packets of signals where each packet includes a preamble defined by a plurality of timing signals and includes a plurality of data signals following the preamble and having individual ones of a plurality of analog levels to represent information,

first means for receiving the signals in each packet,

second means for providing a digital conversion of the received signals in each packet at a particular rate,

third means for operating upon the digital conversions from the second means during the occurrence of the timing signals in the preamble in each packet at times assumed by the third means to constitute the peaks and zero crossings of such digital conversions to determine the amplitudes and polarities of such digital conversions at such assumed times,

fourth means responsive in each cycle of the timing signals in the preamble in each packet to a first relationship in the amplitudes and polarities of the digital conversions at such assumed times in such cycle for providing a first adjustment in subsequent cycles of the timing signals in the times assumed by the third means to constitute the peaks and zero crossings of the digital conversions in the preamble in such packet,

fifth means responsive to the operation of the fourth means in providing the first adjustment in the times assumed by the third means to constitute the peaks and zero crossings of the digital conversions in the preamble of such packet for preventing any further ones of such first adjustments in such assumed times in the preamble in such packet,

sixth means responsive in each cycle of the timing signals in the preamble in each packet to a second relationship in the amplitudes and polarities of the digital conversions at such assumed times in such cycle for providing a second adjustment, less than the first adjustment, in subsequent cycles of the timing signals in the times assumed by the third means to constitute the peaks and zero crossings in the preamble in such packet, and

seventh means responsive to the adjustments in the times assumed by the third means to constitute the peaks and zero crossings of the digital conversions in the preamble in each packet for providing corresponding adjustments in the time for the digital conversion of the data signals in such packet to regulate the digital conversions of the data signals at the particular rate.

77. In a combination as set forth in claim 76,

eighth means responsive to the digital conversions at the particular rate of the data signals following the timing signals in each packet for recovering the information represented by such data signals.

78. In a combination as set forth in claim 76,

eighth means for preventing adjustments in the times assumed by the third means to constitute the peaks and zero crossings of the digital conversions during the preamble in each packet after a particular number of timing signals has occurred in such preamble.

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79. In a combination as set forth in claim 76,

eighth means responsive to the digital conversions by the second means for determining, for each of the data signals following the preamble in each packet, the individual ones of the amplitude levels closest in the plurality to the peaks of such digital conversions, and

ninth means responsive to the analog levels determined by the eighth means for recovering the information represented by such analog levels.

80. In a combination as set forth in claim 77,

ninth means for operating upon the digital conversions from the second means, after the preamble in each packet, at times assumed by the ninth means to constitute the peaks and zero crossings of such digital conversions, to determine the amplitudes and polarities of such digital conversions at such assumed time, and

tenth means for operating upon the digital conversions from the second means, after the preamble in each packet, to provide adjustments in the times assumed by the ninth means to constitute the peaks and zero crossings of the digital conversions, in accordance with the relative amplitudes and polarities of the digital conversions at the times assumed by the ninth means to constitute the peaks and zero crossings of such digital conversions,

the tenth means being operative to provide adjustments in the times assumed by the ninth means to constitute the peaks and zero crossings of the digital conversions in subsequent cycles of the data signals in the packets.

81. In combination for use in a system having a hub for providing packets of signals where each packet includes a preamble defined by a plurality of timing signals and includes a plurality of data signals following the preamble and having individual ones of a plurality of analog levels to represent information,

first means for receiving the signals in each packet,

second means for providing a digital conversion at a particular rate of the received signals in each packet,

third means for determining, for each of the digital conversions following the preamble in each packet, the individual one of the analog levels closest in magnitude to the peak of such digital conversions,

fourth means for operating upon the digital conversions from the second means, during the occurrence of the data signals following the preamble in each packet, at times assumed by the fourth means to constitute the peaks and zero crossings in such digital conversions to respectively determine the amplitude levels from the second means at such assumed times,

fifth means responsive to the amplitude levels determined by the fourth means for each digital conversion of the data signals for providing adjustments in the rate of the digital conversions by the second means to regulate such digital conversions at the particular rate, and

sixth means for preventing the operation of the fourth means during the occurrence of the timing signals in each packet and during the time between the occurrence of successive packets.

82. In a combination as set forth in claim 81,

seventh means responsive to the individual ones of the analog levels determined by the fourth means for decoding such analog levels to recover the information represented by such analog levels.

83. In a combination as set forth in claim 81,

the fifth means including seventh means responsive in a first relationship to a first pattern of the amplitude

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levels determined by the fifth means at the times assumed by the fourth means to be the peaks and zero crossings of the digital conversions from the second means for providing first adjustments in the rate of such digital conversions, and

the fifth means including eighth means responsive in a second relationship to a second pattern of the amplitude levels determined by the fifth means at the times assumed by the fifth means to be the peaks and zero crossings of the digital conversions for providing second adjustments in the rate of such digital conversions,

the second adjustments being different from the first adjustments.

84. In a combination as set forth in claim **83**,

the amplitude levels of the digital conversions in the first pattern providing a transition between amplitude levels of one polarity. and amplitude levels of the opposite polarity,

thc amplitude levels of the digital conversions in the second pattern constituting amplitude levels of the same polarity,

the seventh means being operative with a higher gain factor than the eighth means.

85. In combination for use in a system having a hub for providing packets of signals where each packet includes a preamble defined by a plurality of timing signals and includes a plurality of data signals having individual ones of a plurality of analog levels to represent information,

first means for receiving the signals in each packet,

second means responsive to the signals received in each packet for providing a digital conversion of such signals at a particular rate,

third means for determining the phase and amplitude of the digital conversions from the second means at the times assumed by the third means to be the peaks and zero crossings of such digital conversions,

fourth means responsive to the phases and amplitudes determined by the third means during the timing signals in the preamble in each packet for providing first adjustments in the rate of such digital conversions to regulate the digital conversions at the particular rate,

fifth means responsive to each digital conversion following the preamble in each packet for selecting the analog level closest in the plurality to the peak assumed by the third means in such digital conversion, and

sixth means responsive to the phases and amplitudes determined by the third means in the digital conversion during the data signals in each packet for providing second adjustments in the rate of such digital conversions to regulate at the particular rate the digital conversions of the data signals.

86. In a combination as set forth in claim **85**,

the fourth means providing the first adjustments at a higher gain factor than the gain factor of the second adjustments provided by the sixth means.

87. In a combination as set forth in claim **86**,

seventh means for activating the fifth and sixth means only during the occurrence of the data signals following the preamble in each packet.

88. In a combination as set forth in claim **85**,

seventh means responsive to the analog levels selected by the fifth means for converting such analog levels to the information represented by the data signals following the preamble in each packet.

89. In a combination as set forth in claim **85**,

the fnurth means including seventh means responsive to a first relationship in the phases and amplitudes nf the peaks and zero crossings determined by the fnurth means in the preamble in each packet for providing a phase inversinn in the times fnr such determinatinns nf the peaks and zero crossings during such preamble in such packet,

the fnurth means including eighth means respnnsive tn a second relationship in the phases and amplitudes nf the peaks and zero crossings determined by the fourth means in the preamble in each packet fnr providing adjustments, less in phase than the phase inversion, in the times fnr the determinations of such peaks and zero crnssings during such preamble in such packet.

90. In a cnmbination as set forth in claim **89**,

ninth means for limiting the nperation nf the seventh means tn provide only nne phase inversinn in the times for the determinatinn nf the peaks and zero crossings in the preamble in each packet.

91. In a combinatinn as set forth in claim **85**,

seventh means fnr providing fnr the operation of the fnurth means only during the occurrence nf a first particular number of timing signals in the preamble in each packet.

92. In a combination as set forth in claim **89**,

the fnurth means prnviding the first adjustments at a higher gain factnr than the gain factnr of the second adjustments provided by the sixth means,

ninth means for activating the fifth and sixth means nnly during the nccurrence of the data signals following the preamble in each packet,

tenth means for limiting the operation of the seventh means tn nnly nne phase inversinn in the times for the determinatinn nf the peaks and zero crnssings in the preamble in each packet,

eleventh means fnr activating the fnurth means only during the first occurrence nf a particular number nf timing signals in the preamble in each packet, and

twelfth means respnnsive to the analog levels selected by the fifth means fnr converting such analng levels to the infnrmation represented by the data signals fnllnwing the preamble in each packet.

93. In cnmbinatinn fnr use in a system having a hub fnr providing packets of signals where each packet includes a preamble defined by a plurality of timing signals and includes a plurality nf data signals having individual ones of a plurality of analog levels tn represent infnrmatinn,

first means for receiving the signals in each packet,

second means responsive to the signals received in each packet for providing a digital conversion of such signals at a particular rate,

third means for determining the phases and amplitudes nf the digital conversions from the second means at times assumed by the third means tn be the peaks and zero crossings nf such digital cnnversinns,

fourth means respnnsive to the amplitudes and phases of the peaks and zero crossings determined by the third means in the preamble in each packet fnr adjusting the rate nf such digital conversinns in accordance with such amplitudes and phases tn regulate the digital cnnversions at the particular rate,

fifth means fnr bonsting the gain nf the digital cnnversinns frnm the second means when the amplitudes nf the peaks and zero crossings from the second means are belnw a particular value, and

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sixth means responsive to the digital conversions from the second means for recovering tbe information represented by the digital conversions following the preamble in each packet.

94. In a combination as set forth in claim 93,

the fifth means boosting the gain of the digital conversions by a first particular value when the amplitudes of the peaks and zero crossings from the second means are below a first particular value, and

seventh means for boosting the gain of the digital conversions by a second particular value greater than the first particular value when the amplitudes of the peaks and zero crossings determined by the second means are below a second particular value less than the first particular value.

95. In a combination as set forth in claim 93,

seventh means for providing a phase inversion in the times of the determinations of the peaks and zero crossings by the second means in the timing signals when the amplitudes of such determinations in such timing signals have a particular relationship, thereby to adjust the rate of the digital conversions in a direction to regulate the digital conversions at the particular rate, and

eighth means for preventing any other adjustments in the rate of the digital conversions at the time that the phase inversion is being provided by the seventh means.

96. In a combination as set forth in claim 93,

seventh means responsive to the signals received in each packet for providing an automatic gain control in sucb signals,

the second means being responsive to the signals from the seventh means for providing the digital conversion of such signals at the particular rate.

97. In a combination as set forth in claim 93,

a ring oscillator formed from a plurality of amplifiers connected in a sequence in a closed loop, each of the amplifiers in the sequence being connected to provide an output signal at the particular rate with a phase adjusted by a particular magnitude from the phase of the output signal in the previous amplifier in the sequence, and

seventh means operatively coupled to the amplifiers in the ring oscillator and to the fourth means for selecting an individual one of the amplifiers in accordance with the adjustments provided by the fourth means to obtain the digital conversions by the second means at the particular rate.

98. In a combination as set forth in claim 93,

seventh means for providing a phase inversion in the times of the determination by the second means of the peaks and zero crossings in the digital conversions of the timing signals when the amplitudes of sucb determinations in such timing signals have a particular relationship, thereby to minimize the time for adjusting the rate of the digital conversions to the particular value, and

eighth means for limiting the magnitudes in the adjustments of the rate of the digital conversions in the timing signals at the times after the phase inversions.

99. In combination for use in a system having a bub for providing packets of signals where each packet includes a preamble defined by a plurality of timing signals and includes a plurality of data signals having individual ones of a plurality of analog levels to represent information,

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first means for receiving the signals in each packet,

second means responsive to the signals received in each packet for providing a digital conversion of such signals at a particular rate,

third means for determining the magnitudes of the digital conversions from the second means at the times assumed by the third means to be the peaks and zero crossings of such digital conversions,

fourth means responsive to the magnitudes of the peaks and zero crossings determined by the third means in each preamble in each packet for providing first adjustments in the rate of such digital conversions when the magnitudes of such determinations have a first particular relationship, thereby to regulate the digital conversions at the particular rate,

fifth means for providing a phase inversion in the times of the determinations of the peaks and zero crossings by the third means of the digital conversions in the timing signals when the magnitudes of such determinations have a second particular relationship different from the first particular relationship, thereby to adjust the rate of the digital conversions in a direction to regulate the digital conversions at the particular rate,

the phase inversions being greater in phase than the first adjustments, and

sixth means for preventing any other adjustments in the rate of the digital conversions at the time that the phase inversion is being provided by the fifth means.

100. In a combination as set forth in claim **99,**

seventh means responsive to the signals received in each packet for providing an automatic gain control in such signals,

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the second means being responsive to the signals from the seventh means for selectively providing the digital conversion of such signals at the particular rate.

101. In a combination as set forth in claim **99**,

a ring oscillator formed from a plurality of amplifiers connected in a sequence in a closed loop, each of the amplifiers in the sequence being connected to provide an output signal at the particular rate with a phase adjusted by a particular magnitude from the phase of the output signal in the previous amplifier in the sequence, and

seventh means operatively coupled to the amplifiers in the ring oscillator and to the fourth means for selecting an individual one of the amplifiers in accordance with the adjustments provided by the fourth means to obtain the digital conversions by the second means at the particular rate.

102. In a combination as recited in claim **99**,

eighth means for limiting the magnitudes in the adjustments of the rate of the digital conversions at the times after the phase inversions.

103. In a combination as set forth in claim **99**,

seventh means for boosting the gain of the digital conversions by the second means when the magnitudes of the determinations of the peaks and zero crossings by the third means of the digital conversions are below a particular value, and

eighth means responsive to the digital conversions from the second means for recovering the information represented by the digital conversions of the data signals following the preamble in each packet.

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104. A method of processing signals transmitted through a transmission medium and having predetermined characteristics at particular phases in the signals, comprising the steps of:

receiving the signals from the transmission medium,

providing timing signals having the particular phases and having the predetermined characteristics at the particular phases in the timing signals,

digitally processing the received signals, and

adjusting the phases of the digitally processed signals to have the times for the occurrence of the predetermined characteristics in the digitally processed-signals coincide with the times for the occurrence of the predetermined characteristics in the timing signals.

105. A method as set forth in claim 104 wherein

the timing signals have peaks and zero crossings and wherein the predetermined characteristics in the timing signals constitute the peaks and zero crossings of the timing signals and wherein

the digitally processed signals have peaks and zero crossings and wherein the predetermined characteristics in the digitally processed signals constitute the peaks and zero crossings of the digitally processed signals.

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106. A method as set forth in claim 104 wherein

the received signals are provided in packets and wherein

the received signals in each packet include timing signals in a preamble and data signals following the preamble and wherein

the digitally processed signals receiving in each packet the adjustments in the phases constitute the timing signals in the preamble in the packet.

107. A method as set forth in claim 106 wherein

the data signals in each packet have amplitudes providing data and wherein

the data signals in each packet are processed, after the adjustments in the phases of the timing signals in the packet, to recover the amplitudes of the data signals in the packet.

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108. A method as set forth in claim 106 wherein

the digitally processed signals receiving in each packet the adjustments in the phases of the digitally processed signals also constitute the data signals in the packet.

109. A method as set forth in claim 108 wherein

the adjustments in the phases of the timing signals in each packet are greater than the adjustments in the phases of the data signals in the packet.

110. A method as set forth in claim 106 wherein

the preamble in each packet includes a particular number of the timing signals and wherein

the adjustments are made in the phases of only first ones of the particular number of the timing signals in the preamble in each packet.

111. A method of operating upon signal packets each including a plurality of signals having predetermined characteristics, comprising the steps of:

receiving the signal packets,

providing a plurality of timing signals each having predetermined characteristics at particular phases in the timing signals,

selecting predicted times, in the received signals in the packets, at which the predetermined characteristics in the timing signals are predicted to occur,

determining any phase differences between the predicted times, and the actual times, for the occurrence of the predetermined characteristics of the timing signals, and Amp

adjusting the predicted times of the occurrence of the predetermined characteristics of the timing signals to eliminate any differences between the predicted times, and the actual times, for the occurrence of the predetermined characteristics of the timing signals.

112. A method as set forth in claim 111 wherein signals in the packets have amplitudes providing data, including the step of:

determining the amplitudes of the received signals in the packets after adjustments have been made in the phases of the received signals at which the particular characteristics of the timing signals are predicted to occur.

113. A method of operating upon signal packets each including a plurality of signals, comprising the steps of:

receiving the signal packets,

providing a plurality of timing signals each having successive peaks and zero crossings,

selecting predicted times, in the received signals in the packets, at which the peaks and zero crossings in the timing signals are predicted to occur,

determining any differences between the selected times, and the actual times, for the occurrence of the peaks of the timing signals and any differences between the selected times, and the actual times, for the occurrence of the zero crossings of the timing signals, and

adjusting the predicted times of the occurrence of the peaks and zero crossings of the timing signals to eliminate any differences between the predicted times, and the actual times, for the occurrence of the peaks of the timing signals and to eliminate any differences between the predicted times, and the actual times, of the occurrence of the zero crossings of the timing signals.

114. A method as set forth in claim 113 wherein signals in the packets have amplitudes providing data, including the step of:

determining the amplitudes of the received signals in the packets at the predicted times of the occurrence of the peaks of the timing signals after adjustments have been made in the predicted times at which the peaks and zero crossings of the timing signals are predicted to occur.

115. A method of operating upon signal packets each including a plurality of signals with each signal having an individual one of a plurality of different characteristics, comprising the steps of:

receiving the signal packets,

providing a plurality of successive timing signals,

selecting predicted times, in the received signals in the packets, at which the timing signals are predicted to provide for the occurrence of the individual ones of the particular characteristics in the successive ones of the received signals,

determining any difference between the predicted times, and the actual times, at which the timing signals provide for the occurrence of the individual ones of the particular characteristics in the successive ones of the received signals, and

adjusting the particular times at which the successive ones of the timing signals provide for the occurrence of the individual ones of the particular characteristics in the successive ones of the received signals, the adjustment being in a direction to eliminate any difference between the predicted times, and the actual times, at which the successive ones of the timing signals provide for the occurrence of the individual ones of the particular characteristics in the successive ones of the received signals.

116. A method as set forth in claim 115 wherein

each of the timing signals has predetermined properties at particular phases in the timing signals and wherein

each of the received signals has the particular phases and has the predetermined properties at the particular phases in the timing signals and wherein

the received signals are digitally processed and wherein

the method additionally comprises the steps of:

predicting the times of occurrence of the predetermined properties of the digitally processed signals, and

adjusting the phases of the digitally processed signals to have the times for the occurrence of the predetermined properties in the digitally processed signals coincide with the times for the occurrence of the predetermined properties in the timing signals.

117. A method of operating upon signal packets each including a plurality of signals with each signal having an amplitude level of + 1, 0 or -1 to indicate data, comprising the steps of:

receiving the signal packets,

providing a plurality of timing signals each providing at a particular time in the timing signal for one of the amplitude levels of + 1, 0 or -1 to be indicated in one of the signals in the signal packet,

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selecting predicted times, in the received signals in the packets, at which the timing signals are predicted to provide for the occurrence of the indications of the amplitude of + 1, 0 or -1 in the successive ones of the received signals,

determining any difference between the selected times, and the actual times, at which successive ones of the timing signals provide for the occurrence of an indication of a crossover through an amplitude of 0 from an amplitude of +1 or an amplitude of -1 in successive ones of the received signals in the signal packets, and

adjusting the predicted times at which the successive ones of the timing signals provide for the occurrence of an indication of a crossover through the amplitude of 0 from the amplitude of +1 or the amplitude of -1 in the successive ones of the received signals, the adjustment being in a direction to eliminate any difference between the predicted times, and the actual times, at which the successive ones of the timing signals provide for the occurrence of an indication of the crossover through the amplitude of 0 from the amplitude of +1 or the amplitude of -1 in the successive ones of the received signals.

118. A method as set forth in claim 117, including the step of:

determining the amplitudes of the received signals in the packets at the predicted times at which the successive ones of the timing signals provide for the occurrence of an indication of the crossover through the amplitude of 0 from the amplitude of +1 or the amplitude of -1 in the successive ones of the received signals, this determination being provided after adjustments have been made in the predicted times at which the successive ones of the timing signals provide for the occurrence of an indication of the crossover through the amplitude of 0 from the amplitude of +1 or the amplitude of -1 in the successive ones of the received signals.

119. A method of operating upon signal packets each including a plurality of analog signals, comprising the steps of:

receiving the analog signals,

converting the analog signals to digital signals,

operating upon the digital signals to provide timing recovery signals indicating changes in the frequency of the digital signals from a particular value, and

using the timing recovery signals to regulate the frequency of the conversion of the analog signals to the digital signals at the particular value.

120. A method as set forth in claim 119 wherein

the analog signals are received in twisted pairs of wire and wherein

the signals received in the twisted pairs of wires are converted to the digital signals.

121. A method as set forth in claim 119 wherein

the analog signals are provided with an automatic gain control and wherein

the gain of the digitally converted signals is regulated and wherein

the automatic gain control of the analog signals is regulated in accordance with the regulated gain of the digital signals.

122. A method as set forth in claim 121 wherein

the analog signals are provided with different amplitude values representing data and wherein

the amplitudes of the digital signals are recovered after the automatic gain control of the analog signals has been regulated.

123. A method of operating upon signal packets each including a plurality of analog signals which are provided with a limited number of different amplitudes representing data, comprising the steps of:

receiving the analog signals,

providing the analog signals with an automatic gain control,

converting the analog signals with the automatic gain control to digital signals,

regulating the gain of the digital signals at a particular value, and

regulating the automatic gain control of the analog signals in accordance with the regulated gain of the digital signals.

124. A method as set forth in claim 123, including the step of:

operating upon the digital signals to recover the amplitudes of the digital signals.

125. A method as set forth in claim 124 wherein

the analog signals are received in twisted pairs of wires and wherein

the signals received in the twisted pairs of wires are converted to the digital signals.

126. A method of operating upon signal packets each including a plurality of analog signals which are provided with a limited number of different amplitudes representing data, comprising the steps of:

receiving the analog signals,

providing a digital adaptive equalization of the digital signals, and

recovering the amplitudes of the signals after the digital adaptive equalization.

127. A method as set forth in claim 126, including the steps of:

operating upon the digital signals to provide timing recovery signals, and

using the timing recovery signals to regulate the frequency of the digital conversion of the analog signals at a particular value.

128. A method as set forth in claim 127, including the steps of:

providing an automatic gain control of the analog signals,

providing a regulation of the gain of the digital signals, and

regulating the automatic gain control of the analog signals in accordance with the regulation of the gain of the digital signals.

129. A method as set forth in claim 126 wherein

the analog signals are received in twisted pairs of wires and wherein

the signals received in the twisted pairs of wires are converted to the digital signals and wherein

an automatic gain control of the analog signals is provided and wherein

the gain of the digital signals is regulated and wherein

the automatic gain control of the analog signals is regulated in accordance with the regulation of the gain of the digital signals.

Sub A3

130. A bidirectional data communication system comprising:

communication signals having individual ones of a plurality of analog levels to represent information;

a plurality of signal lines disposed in pairs and defining a multi-pair communication environment, each signal line transmitting or receiving said communication signals;

a transmitter block, including a plurality of transmitters, each coupled to particular ones of the signal line pairs;

a receiver block, including a plurality of receivers, each coupled to particular ones of the signal line pairs, each receiver including;

an analog to digital converter configured to convert a plurality of analog levels into a corresponding plurality of digital levels defining a digital signal; and

a digital equalizer coupled to the analog to digital converter and operating on the digital signal to define information represented by the plurality of digital levels.

131. A bidirectional data communication system according to claim 127, the receiver block further comprising timing recovery circuitry coupled to receive the digital signal from the analog to digital converter and extract timing information therefrom, the analog to digital converter operatively responsive to said timing information and performing digital conversions at a rate defined thereby.

Sub A3

132. A bidirectional data communication system according to claim 128, wherein the communication signals are provided in packets, each packet comprising a preamble portion and a data containing portion, the preamble portion including timing signals.

133. A bidirectional data communication system according to claim 129, wherein the timing recovery circuitry comprises a first timing loop having a high gain stage and a second timing loop having a low gain stage, the first timing loop locking the analog to digital converter in phase with the preamble portion the second timing loop locking the analog to digital converter in phase with the data containing portion.

134. A bidirectional data communication system according to claim 130, wherein the first timing loop includes a high gain error generator, a loop filter, and an oscillator circuit, the high gain error generator responsive to characteristic values of the timing signals, and wherein the second timing loop includes a low gain error generator, a loop filter, and an oscillator circuit, the high gain error generator responsive to characteristic values of the data signals.

135. A bidirectional data communication system according to claim 131, the digital equalizer further comprising;

a feed forward equalizer having an input receiving the digital signal from the analog to digital converter and an output;

a slicer coupled to receive the digital signal from the feed forward equalizer and outputting a signal characterized by the digital levels;

an adder disposed between the feed forward equalizer and the slicer; and

a decision feedback equalizer having an input receiving the signal output by the slicer and an output coupled to the adder, the adder summing the output of the decision feedback equalizer with the output of the feed forward equalizer.

136. A bidirectional data communication system according to claim 132, wherein the plurality of signal lines comprises four unshielded twisted pairs defining a local area network.

137. A bidirectional data communication system according to claim 133, wherein the local area network is an ethernet network, the four unshielded twisted pairs comprising a first pair adapted for transmission, second and third pairs adapted for bidirectional transmission and reception, and a fourth pair adapted for reception.

138. A bidirectional data communication system according to claim 134, wherein the communication signals are encoded to one of three analog levels, thereby representing information.

139. A bidirectional data communication system according to claim 135, wherein the transmitter block comprises three transmitters, the transmitters coupled respectively to the first, second and third unshielded twisted wire pairs, and wherein the receiver block comprises three receivers, the receivers coupled respectively to the second, third and fourth unshielded twisted wire pairs.

140. A bidirectional data communication system comprising:

communication signals having individual ones of a plurality of analog levels to represent information;

a plurality of signal lines disposed in pairs and defining a multi-pair communication environment, each signal line transmitting or receiving said communication signals;

a transmitter block, including a plurality of transmitters, each coupled to particular ones of the signal line pairs;

a receiver block, including a plurality of receivers, each coupled to particular ones of the signal line pairs, each receiver including;

an analog to digital converter configured to convert a plurality of analog levels into a corresponding plurality of digital levels defining a digital signal; and

a digital equalizer coupled to the analog to digital converter and operating on the digital signal to define information represented by the plurality of digital levels.

Sub A3 Cont'd

141. A bidirectional data communication system according to claim 137, the digital equalizer further comprising:

a feed forward equalizer having an input receiving the digital signal from the analog to digital converter and an output;

a slicer coupled to receive the digital signal from the feed forward equalizer and outputting a signal characterized by the digital levels;

an adder disposed between the feed forward equalizer and the slicer; and

a decision feedback equalizer having an input receiving the signal output by the slicer and an output coupled to the adder, the adder summing the output of the decision feedback equalizer with the output of the feed forward equalizer.

142. A bidirectional data communication system according to claim 138, the receiver block further comprising timing recovery circuitry coupled to receive the digital signal from the analog to digital converter and extract timing information therefrom, the analog to digital converter operatively responsive to said timing information and performing digital conversions at a rate defined thereby.

143. A bidirectional data communication system according to claim 139, wherein the timing recovery circuitry comprises a first timing loop having a high gain stage and a second timing loop having a low gain stage, the first timing loop locking the analog to digital converter in phase with the preamble portion the second timing loop locking the analog to digital converter in phase with the data containing portion.

144. A bidirectional data communication system according to claim 140, wherein the first timing loop includes a high gain error generator, a loop filter, and an oscillator circuit, the high gain error generator responsive to characteristic values of the timing signals, and wherein the second timing loop includes a low gain error generator, a loop filter, and an

Sub B' cont.

oscillator circuit, the high gain error generator responsive to characteristic values of the data ~~signals.~~

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